

D-3

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1-24
III.D.2.b(1) Concrete-making is intrinsically safer than either glass-making or HIPing (it's done "wet" - generates less dust - and requires much lower temperatures) and is much easier/cheaper to do on an appropriate (large scale). The specific improvements that I and my colleagues have recommended over regular "grouts" (the use of "hydroceramic" rather than regular grout formulations and the calcination (incineration) of everything that would be rendered more suitable for cementitious solidification that way) are to ensure the production of top-quality products - materials distinctly more durable than those which BNFL has recently made out of the UK's "historic waste" and probably also superior to typical radwaste-type glasses. The "Lead lab" should make the DOE Complex's best waste forms.

1-25
III.D.2.b(1) Hydroceramics make especially good sense at INEEL for the following reasons:

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III.D.2.b(1) 1) INEEL has not yet officially committed to any particular way of dealing with its HLW.
- 1-27
III.D.2.b(1) 2) Because INEEL calcines do not contain excessive concentrations of soluble salts, it would be possible to satisfy the "sodalite formulation" rule-of-thumb with high (>25%) waste loadings.
- 1-28
III.D.2.b(1) 3) Since two of the three elements making up HC binder phases (Na & Al) are high-percentage constituents of INEEL calcines, there is no need to separate them (or anything else) prior to solidification. This means that everything would be prepared for offsite disposal - the wish of INEEL's local stakeholders. (A primary goal of the "volume reduction" activities practiced at WVDP and SRS is to transfer those elements to "low level" fractions that aren't vitrified.)
- 1-29
III.D.2.b(1) 4) Simple changes to the existing calcination facility would permit it to efficiently calcine the remaining liquid reprocessing waste - either by itself or (preferably) after it's been slurry-mixed with existing calcines. The latter scenario would consolidate all INEEL reprocessing wastes into a homogeneous feedstream suitable for HC solidification.
- 1-30
III.D.2.b(1) 5) It would also provide a good way to deal with other INEEL radwastes. For example, INEEL must find some way to dispose of ~1000 metric tons of radioactive NaOH generated by reacting metallic sodium reactor coolant with water. Since this just happens to be the same amount of "activator" that would be required to turn ICPP/INTEC's calcines into HC concrete, coprocessing these wastes would solve two problems. If the changes to the existing calcination facility I've alluded to were to be implemented, virtually any sort of liquid or particulate waste (e.g., contaminated soils) could be readily converted to HCs.
- 1-31
III.D.2.b(1) 6) It is probable that a formal proposal to properly implement an HC-type solidification process would satisfy INEEL's stakeholders.
- 1-31
III.D.2.b(1) 7) Finally, if a future generation deems it to be both politically expedient and affordable, HC concrete monoliths could be hot-isostatically-pressed into "vitrified" monoliths without removing them from their original canisters. (This means that today's decision-makers would not have to make an irrevocable commitment to not "vitrifying" this waste.)

Since this EIS is just a "draft", let me suggest some changes for your final version.

1-32
VII.D(2) First, make it very clear up front just exactly what it is you're trying to accomplish. If it's already been decided that it's OK to not honor commitments made in the "Batt Agreement", say so. (For instance, some of the scenarios in this Draft that propose that SBW will be calcined, assume a completion time of 2014 AD, not 2012 AD - does this two-year "slip" reflect a change in policy?)

1-33
IX.A(3) Second, when you present/discuss treatment scenarios that don't seem to make much sense⁴, be sure that you explain the assumptions/conditions that would make them plausible.

⁴for instance, the "Minimum INEEL Processing Alternative" (the "driver" for which is the cost of building a DOE-type vitrification plant here at INEEL) suggests that we are to bundle up our calcines into some sort of transportable (you can't ship powders) temporary waste form (RTV-type rubber cement is being proposed for this purpose) & then ship it all off to Hanford where they will somehow undo our temporary solidification process, separate the stuff into various fractions, vitrify(?) all of them, and then ship it all back here for a few(?) decades worth of "interim" storage. This is too clever to make much sense to the casual reader unless additional background is provided.

1-34
III.D.1(6) Third, you might want to consider integrating some of this Site's other waste treatment/disposal problems into your final version (e.g., using ANLW's caustic as the activator for "hydroceramics" made out of INTEC calcines.) Doing so would prevent a lot of unnecessary duplication, cause a higher percentage of INEEL's radwaste to be prepared for offsite disposal (which would delight local stakeholders), and save taxpayers a lot of money. (The "stove piping" of EM projects to match existing organizational structures/definitions is another of the "symptoms" identified in "Barriers to Science".)

1-35
III.D.4(6) Fourth, when you present/discuss treatment scenarios that have not received programmatic research support, e.g., "Direct Cement/Hydroceramics", make it clear to the reader that that's indeed been the case & also that information about them can be obtained from sources other than therefore non-existent official Government reports. (For example, I've co-authored/published a dozen research papers that anyone interested in why "direct cement" makes sense might want to see - the "Draft EIS" doesn't acknowledge that this sort of technical literature even exists.)

1-36
III.D.4(6) Fifth, to ensure that your EIS-preparation subcontractors do a better job of representing alternatives like "Direct Cement" in the final version, insist that they actually contact the persons responsible for developing/championing them - the "draft" doesn't accurately represent what my colleagues & I have done or would recommend.

1-37
III.F.2(1) Sixth & finally, please don't characterize DOE's decision to tell its employees & contractors to assume that all waste forms made from it's reprocessing waste will have 0.5 MTHU/m³ as being merely "controversial" (p. S-21). A policy that is inconsistent with both the intent and letter of the law (see 40 CFR 191) and is largely responsible for DOE's inability to deal efficiently with its own "high level" waste requires a more forceful adjective.

1-38
IX.A(2) Do not change your Publisher. The quality of the photography, printing, general layout, etc. of this EIS is the best I've ever seen in a large government-sponsored document.

1-39
III.D.2.b(1) If you would like to read some technical stuff that's not in a DOE-sponsored report, I've written up another research paper (at this point, it is also just a "draft") discussing why "Direct Cement" makes especially good sense for INEEL. It goes into a good bit of detail about vitrification's drawbacks (one of which is that its prohibitive cost encourages folks to do "separations") and compares leach test performance of radwaste type glasses with "hydroceramics". It's an "easy read" because it's written like the stuff you find in trade journals like *Radwaste Magazine*. Its literature references (35 of them) support the "controversial" contentions I've made in this review. Let me know if you would like to see it.

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WHY HYDROCERAMIC SOLIDIFICATION MAKES MORE SENSE THAN VITRIFICATION
INEEL HIGH LEVEL WASTE

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ABSTRACT

"Hydroceramics" (HC) are alkali aluminosilicate ("geopolymeric") concretes designed to match the leach test performance of radwaste-type glasses. They are made by curing grouts consisting of mixtures of calcined waste, calcined clay, water, and NaOH under hydrothermal conditions. This paper characterizes them and explains why this approach to radwaste treatment would be preferable to vitrification for the Idaho National Engineering and Environmental Laboratory's (INEEL) reprocessing waste.

INTRODUCTION

In 1970, Idaho's political leadership was told that the "high level waste" (HLW) generated by the Federal Government's nuclear fuel reprocessing facility at INEEL (then "NRTS") would be prepared for offsite disposal (i.e., rendered "road ready") by 1980¹. Since then, billions of taxdollars have been spent on HLW management paperwork, no HLW repository has been provided, none of INEEL's reprocessing waste has been rendered road-ready, and today's official deadline for accomplishing it has slipped to 2035 AD². A recent National Research Council (NRC) report identified the management "symptoms" responsible for this situation³. One of these is that DOE habitually blinders itself to any but predetermined "preferred alternatives" when deciding how to go about solving problems. This paper discusses one "preferred alternative", vitrification, and describes why a particular cementitious technology ought to be used instead.

VITRIFICATION'S DRAWBACKS

During the past three years DOE's contractors have managed to operate two full-scale glass melters long enough to establish that the cost of solidifying its HLW that way will be 2-4 \$million per m³ of glass produced⁴. Because DOE must eventually process ~60,000 m³ of high-solids reprocessing waste (primarily the sludges at its Hanford & SRS facilities) and is unlikely to achieve >100% volumetric loading of those materials into glass, these costs suggest that vitrification will prove to be prohibitively expensive. This was predicted by another "controversial" NRC report published over twenty years ago⁵.

Let's review some of the arguments employed by vitrification's champions.

One of these is, "glass is better because a glass melter can achieve greater volumetric waste loading than low temperature solidification technologies". This is both misleading and irrelevant. It's misleading because it presumes that the other technologies *must* be implemented without appropriate waste pretreatment and, also, as I'll demonstrate later, that only a fraction of the waste "counts". Raw reprocessing waste consists primarily of volatile materials such as water, mineral acid, nitrate/nitrite and, in some cases, organic materials which may include "listed" toxins (both real and imaginary), solvents, and chelating agents. Calcination (or "incineration")^{6,7} is a well-developed, technically justifiable, and obvious way to eliminate those components while producing inorganic ash which can be converted to equally low-volume monoliths by other means. While it is true that glass melters may be (and sometimes are) used as "devolatilizers", it is much more efficient to do that operation with equipment optimized for that purpose⁸.

The argument is irrelevant because the notion that the cost of managing this waste will be proportional to the geometric volume of waste forms made from it is invalid. First of all, history suggests that *any* facility run under DOE oversight will cost taxpayers a lot of money whether or not it actually ever produces anything - which, in turn, indicates that today's practice of judging hypothetical waste treatment scenarios based on an assumed proportionality between cost and volume is overly simplistic. [For example, the cost of producing one canister (~1 m³) of any sort of "rock" will be >90% that of making ten canisters (~10 m³)

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of it with the same equipment - most of the total expenditure (research, development, design, licensing, administrative, construction, personnel training, testing, decommissioning, etc., etc.) will be independent of the amount of product made. Producing something adds only an *incremental* cost.] Similarly, the cost of disposing of waste forms produced from DOE HLW will *not* be proportional to their geometric volume. Why? 1) Formal analyses have repeatedly concluded that transport of waste forms to a repository will represent a small fraction of total cost regardless of their volumes⁹. 2) today's official hypothetical HLW repository site, Yucca Mountain (YM), is physically large enough (several cubic miles - several tens of billions of cubic meters) to accommodate any type of material(s) that DOE might choose to make from its reprocessing wastes, 3) YM's capacity is defined in units proportional to the amount of radionuclides to be buried there (the equivalent of that in 70,000 "metric tons of heavy metal"), not that waste's geometric volume¹⁰, and, of course, 4) YM will cost US taxpayers billions of dollars whether or not any real waste is ever buried there. Again, the cost of using the facility for its intended purpose will add only a relatively small *incremental* cost attributable to mass/volume.

Today's tendency to assign undue weight to "volume" is harmful because doing so diverts both attention and resources from rendering waste road-ready to changing its classification via "volume reduction". Existing defense-type HLWs should be rendered road-ready because they are toxic, radioactive, corrosive, situated in places poorly suited to become permanent geological repository sites, and have already been neglected for far too long - not because they are "big" or "high". "Devolatilization" via calcination/incineration and physical compaction of compressible solids are the only volume reduction technologies that make much sense. In practice, most of the separation technologies used/proposed to effect reclassification decrease the physical size of "high activity" fractions that "must be vitrified" for offsite disposal by increasing those of "low level" fractions destined to be left on-site with little or no further treatment. The latter usually contain the bulk of the original waste's infinite half-life toxic components and, due to the process chemicals added to affect the separation(s), is generally larger (often much larger) in terms of total mass, solids content, and volume than the waste was before it was fractionated. Stratagems used/proposed to achieve enough "volume reduction" to make the vitrification of the "high" stuff in DOE's reprocessing waste more affordable range from the relatively straightforward sludge-washing done at WVDP & SRS to the "full separation" scheme championed by INEEL's decision-makers during most of the 1990s. History suggests that the "volume reduction" of existing reprocessing waste is attractive primarily to those who would be employed designing/building/operating the facilities required to do it - and equally unattractive to independent reviewers¹⁰ and folks who live near the site in question but do not derive their incomes from it¹¹.

Another argument proffered for vitrification consists of a strained analogy; i.e., "because France and Great Britain vitrify their high-level reprocessing wastes, it must be 'best' for US HLW too". This is invalid because about the only characteristic that these wastes have in common is their name. European HLW consists of relatively "young", first-cycle, PUREX-type raffinates generated by the nitric acid dissolution of mechanically-declad commercial reactor fuel. Fission products typically comprise 20-60% of the non-volatile matter in them. On the other hand, today's DOE HLW is "old" (typically >30 years out-of-reactor) and consists primarily of non-radioactive materials derived from fuel cladding and involatile process reagents. Consequently, DOE's HLWs are typically 2 orders of magnitude less radioactive and much more heterogeneous than their European namesakes. The "technical" reason why vitrification of US HLW is prohibitively expensive is that a US melter capable of solidifying any given amount of "bad stuff" must be ~100 times larger and able to safely accommodate a much wider range of feedstocks than its European counterpart ("bad stuff" = the sum of RCRA metals + fission products + TRU).

A more fundamental weakness of glasses for this application is that they are "ineluctably metastable"¹². Glasses are rare in Nature because they are unstable with respect to crystalline minerals/rocks and therefore inevitably decompose to form them; e.g., the "zeolitized tuff" that makes up much of today's official hypothetical HLW repository site was originally volcanic glass. Radwaste-type glasses (i.e., ones with relatively low percentages of silica and alumina & high percentages of alkalis and boron) are apt to be especially unstable. Furthermore, because both materials tend to enhance the corrosion rate of glasses under certain conditions¹², some of DOE's radwaste management experts are now suggesting that its proposed HLW repository must be implemented without the use of concretes for construction or clays for backfill -